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PUBLICATIONS
OF THE
Astronomical Society of the Pacific.

VOL. XVI. SAN FRANCISCO, CALIFORNIA, DECEMBER 10, 1904. No. 99.

ON DOUBLE STARS.*

By R. G. AITKEN.

In the ten minutes allotted to me this morning I wish to offer some general considerations relating to double-star astronomy, to describe more particularly the work now in progress at the Lick Observatory, and to make some suggestions as to the lines of future investigation that seem to me to promise the largest returns for the time and labor invested.

Only a century has passed since Sir WILLIAM HERSCHEL announced the existence of physical systems among the stars, and but little more than three quarters of a century since STRUVE laid the sure foundations for a new department of sidereal astronomy by the publication of the "Mensuræ Micrometricæ." From an astronomer's view-point, these are short periods, and double-star astronomy is still in the primary stages of its development. Still, far more has been accomplished by the zealous efforts of its devotees than can be mentioned even briefly in the limits of this paper.

Taking account only of the double stars within 120° of the North Pole, BURNHAM, in 1896, found that nearly eleven thousand objects were included in the published catalogues. Less that half this number deserved the name of double star, judged by our present standards; for in the absence of any criterion based upon observation, the earlier observers very properly made their limits much wider than would be excusable to-day. Of the four thousand or five thousand objects that might fairly be called double stars, not more than eighteen hundred had distances of 2″ or less. Nearly eight hundred of these close pairs were discovered by BURNHAM himself, and many of the others were added by HOUGH, SEE, and other recent observers. Between two hundred and three hundred pairs had given definite evidence of orbital motion, and in about fifty cases the observed motion was sufficiently great to form the basis for approximately accurate orbits.

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* Read before the Section Astrometry, International Congress of Arts and Science, St. Louis, September 21, 1904.

During the nineteenth century astronomers devoted a great deal of time to the important task of measuring these double stars, especially those contained in the catalogues of the two STRUVES and of BURNHAM, and a vast amount of observational material was accumulated. Unfortunately these measures as a whole are not readily accessible to observers, being widely scattered through the publications of observatories, the transactions of academies of science, and the scientific periodicals of Europe and America. For this reason much time has been wasted in unnecessary duplication of measures. Even more time, perhaps, has been thrown away because too many observers in their zeal have tried to make measures under unsatisfactory observing conditions and often of objects beyond the power of their telescopes. Such work only introduces confusion, and must ultimately be rejected as valueless.

So far as the double stars already discovered are concerned, I am convinced that our first need is a General Catalogue that will give not only the position of every known double star, with its description, but also enough measures of every pair to show the nature of the motion, if motion has been observed, together with complete references to all published measures. Important contributions in this line have recently been made by INNES with his "Reference Catalogue of Southern Double Stars," and by HUSSEY with his complete monograph on the "Otto Struve Double Stars." A much more important, because far more comprehensive, work is the General Catalogue that BURNHAM has been engaged upon for many years. This work is now in press, and all who are interested in double-star astronomy rejoice at the prospect of its early publication.

In the second place, the experience of the past century has made it clear that the wider double stars of the older catalogues need very little attention, and that even the moderately close pairs—those having distances of from 2″ to 5″—need be measured but once in ten to twenty years. Observers having access to good telescopes should therefore devote their time mainly to the measurement of the double stars with distances under 2″, especially those that have already given evidence of motion and the very close pairs of recent discovery; and they should repeat the measures of the same stars annually or biennially, according to the rapidity of the observed motion, for as many years as possible. Such a systematic series of measures of two hundred or three hundred selected stars, made by a single observer working with an adequate telescope under good conditions, will in twenty years' time add more to our knowledge of the binary systems than sporadic measures of fifty times as many pairs by a dozen observers.

But at the present time, when many leaders of astronomical thought are making extensive researches into stellar statistics, there are other questions relating to double stars, besides the theory of the motion in any particular system or systems, that are of the greatest interest.

What is the number of double stars relatively to all the stars to a given magnitude? Is this ratio the same for the fainter stars as for the brighter ones? Does it vary in different parts of the heavens, and, if so, what is the cause of the variation? These and other questions relating to double-star statistics demand an answer.

The catalogues of the HERSCHELS and the STRUVES do not afford the data needed for investigations of this nature, for the discoveries of BURNHAM, HOUGH, and others have demonstrated that the surveys of these early observers were not nearly so complete as their immediate successors had supposed. And it is also a fact that the work of none of the later double-star observers, not even that of BURNHAM, has been thorough in the sense that every star to a given magnitude in a given sky area has been examined.*

A systematic search for double stars that will include the careful examination of every star to the eighth or ninth magnitude with a good modern telescope under favorable observing conditions is therefore a prime requisite for reliable statistical researches on double stars.

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* This statement, of course, applies only to telescopic stars. BURNHAM has undoubtedly examined every naked-eye star visible in our latitude, most of them repeatedly.

There are other good reasons for making such a survey of the sky. Accurate meridian-circle observations are now extending to the stars of the ninth magnitude, and stars to this magnitude, and even fainter ones, are in daily use as reference-points in the measures of photographic plates. But moderately close double stars are obviously not suited to such uses; yet they will usually escape detection in meridian-circle observations and very often also on the photographic plates.

Such considerations as these led me, in 1899, to begin a systematic examination of all the stars given in the Bonn-Durchmusterung as of the 9.0 magnitude or brighter. This limit was adopted because it would include a number of stars (over one hundred thousand in the northern hemisphere) sufficiently large for reliable statistical studies, and would at the same time include nearly all the stars likely to be observed with accuracy on the meridian.

I had hardly begun my search when I found that Professor HUSSEY had independently decided to undertake a similar piece of work. We at once made plans to divide the field between us and to make our survey thoroughly systematic.

The sky from the North Pole to 22° South Declination was divided into zones of varying width, and these were so apportioned that about half of this sky area was assigned to each observer. We decided to chart to a convenient scale all the stars to be included in our survey, also marking on our charts the position and description of every double star already known. Each star was to be examined on at least one good night, and every new double star found whose components were separated by $5''$ or less was to be measured on two or more nights and catalogued. We adopted this limit of distance after a careful consideration of the known binary systems as being wide enough to include all pairs at all likely to prove of interest as binaries. At the same time this limit was none too wide if we wished our lists to include all pairs likely to affect meridian observations or the measures of photographic plates.

Having formulated our general programme, we have given part of our time for the past few years to its execution, each observer working independently but in entire harmony with the other. Our survey is not quite half completed, but the results already obtained have far exceeded our expectations.

At the present time* Professor HUSSEY has found 1,035 new pairs, while my own discoveries exceed 875. These new pairs are practically all within our limit of 5″, seventy-three per cent. of them have distances of 2″ or less, and 142 are very close pairs, with distances under 0″.25. The number of pairs of this latter class in all other catalogues combined is less than 100.

I have made counts in several zones 4° wide, and from 90° to 360° long, which I have thoroughly examined, including in all more than twelve thousand stars to the 9.0 magnitude. In these zones the ratio of new double stars to the whole number of stars examined varies from 1 : 27 to 1 : 36; hence I conclude that a ratio of 3 : 100 will be a fair average for the whole region so far surveyed. This ratio refers only to the new discoveries. When we include such of the double stars previously known as fall within our limits of magnitude and distance, counts that I have made in two long zones show that the ratio of double stars under 5″ to all the stars to 9.0 magnitude is 1 : 18 or 1 : 20.

New pairs are found as readily in the well-observed northern sky as in the zones south of the equator, but neither the new pairs nor those previously known are uniformly distributed over the sky. There are large areas that contain very few known double stars in which we have added but few new pairs. In other large areas the ratio of double stars to all stars to 9.0 magnitude rises as high as 1 : 8. It is clear that such facts as these have a physical significance, and must be taken into account in framing adequate theories of cosmogony.

These ratios are only first approximations, but we are satisfied that, when our programme is fully carried out, our charts will afford ample data for the discussion of all statistical questions relating to the double stars within 112° of the North Pole. Of course, we do not suppose our search to be exhaustive, but we have very good reasons for thinking that the percentage of visual double stars that are overlooked is too small to have any sensible effect upon general conclusions.

No argument is needed to show the desirability of extending to the South Pole the search for new double stars on the systematic plan of the survey now in progress at the Lick Observatory. Indeed, when we consider how little attention the southern double stars have received in the past and how completely they are being neglected at present, it is clear that this is the most important double-star work that can now be undertaken,—especially if the programme is made to include the remeasurement of the closer pairs already known.

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* September 10, 1904.

From our experience at the Lick Observatory, it is my opinion that such a survey can be carried out by a single observer in four or five years' time, provided his telescope is as favorably located as those on Mt. Hamilton, and that a refractor of from twenty-four to twenty-seven inches aperture, all things considered, is best adapted to the work.

We find that on good nights (seeing three or more on a scale of five) we can examine from two hundred to two hundred and fifty stars per night without undue strain upon our eyes. Assuming that the number of stars to 9.0 magnitude in the southern hemisphere is not much greater than in the northern, six hundred nights would suffice to examine the stars to this magnitude south of —22° Declination, and to measure on two or three different nights each new double star discovered. At Mt. Hamilton, six hundred good nights would ordinarily mean about four years' time.

Examination of the catalogues of double stars discovered at the Lick Observatory will show that very few pairs are closer than 0″.15, and that the percentage of pairs with one component fainter than 14.5 magnitude is also very small. The visual double stars, therefore, that are beyond the reach of a good 24-inch refractor are so few that such a telescope is adequate to the work, and the greater ease with which it can be handled, as well as the small relative cost, seems to recommend it for this purpose even in preference to another 36-inch. This assumes, of course, that the mechanism of the mounting, dome, and floor of the smaller telescope is as perfect and as convenient for the observer as that of our 36-inch.

When such a survey of the entire sky has been made it will be possible to discuss double-star statistics with reasonable assurance of reaching definite and reliable conclusions. This alone will be ample compensation for the labor and time required to carry it out. The very large number of interesting binary systems it will certainly reveal to us is a strong additional incentive to the work.